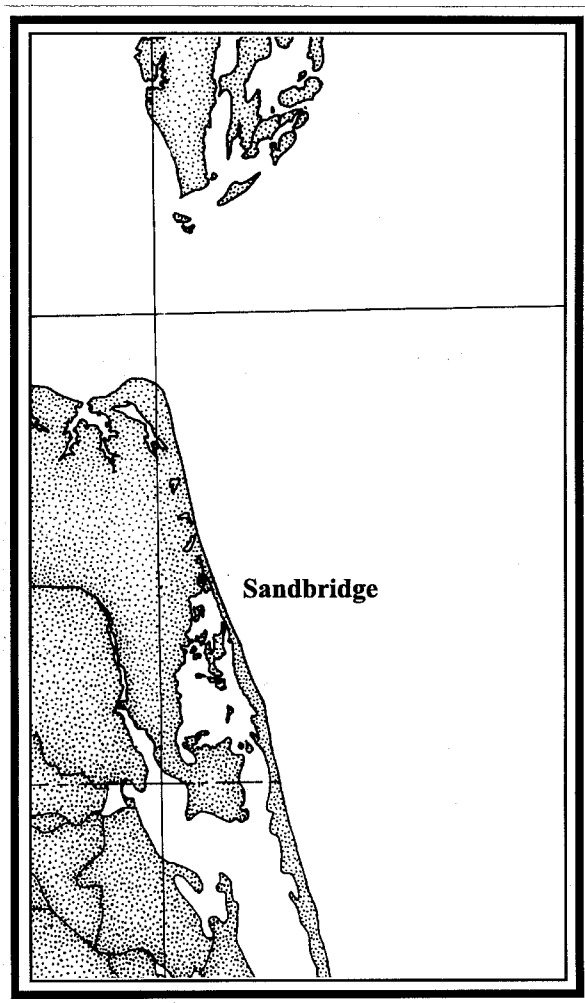
Environmental Studies Relative to Potential Sand Mining in the Vicinity of the City of Virginia Beach, Virginia

Part 4: Coastal Currents

Final Report

January 1998



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The dynamics and structure of currents in the vicinity of Virginia Beach

This document reports on the activities performed by A. Valle-Levinson and L.P. Atkinson under the project funded by the U.S. Minerals Management Service under Cooperative Agreement No. 14-35-0001-30807 with the Virginia Institute of Marine Science. The activities consisted of a series of seven cruises at and off the Chesapeake Bay entrance. The cruises took place in September 1995, March 1996, June 1996, September 1996, November 1996, February 1997, and May 1997. The main objective of these cruises was to determine the influence of bathymetric variations on the flow field in the area of study. Water density and current velocity data were collected during each of those cruises. Most of the current velocity measurements were collected with an acoustic Doppler current profiler (ADCP), which gave high spatial resolution (approximately 75 m) of the water velocity field under different conditions of river discharge, tidal forcing, and wind forcing. This project has contributed to educational activities within the Oceanography Department, Old Dominion University, as it has supported two graduate students: K. Holderied and E. Haskell. The participation of more than twenty people on all the cruises has allowed them to become familiar with state-of-the-art technology in current velocity measuring techniques. The results of this effort have produced five manuscripts that have been submitted for publication in peer-reviewed literature. Two of these manuscripts have already been accepted for publication. These manuscripts are follow and constitute the bulk of the report for this segment of the MMS funded project.

The main finding of this work is that bathymetry plays a crucial role in influencing the shape and strength of the flows in the study area. The dynamics in the relatively deep channel appears to be fundamentally different from that of the adjacent shoals. The results suggest that the subtidal flows in the channel are mainly produced by density gradients that are modified by friction arising from bottom stresses, vertical mixing, and wind stresses. In contrast, the subtidal flows over the sallow regions may be produced by tidal forcing (tidal residual) modified by wind stresses. The tidal flows are in general stronger along the Chesapeake Channel (the channel entering Chesapeake Bay) and lag behind those over the shoals by up to three hours at the entrance to the bay. These large phase lags in the tidal flows allow the development of flow convergences (flow in opposite directions) that persist between 1 and 2 hours at the transition between channel and shoals. These convergences give rise to frontal features that accumulate material at the surface. The results from these studies suggest that changes in bathymetry of approximately 50% (or more) relative to the ambient depth (e.g. from 10 m to 15 m) produce significant alterations to the tidal and subtidal flows. If the sand borrow area off Sandbridge, Virginia, were to be flattened relative to its surrounding depths, the effects of this change on the flow field in the area would probably be less than the effects caused by a depression in the bathymetry relative to the surroundings.

(Project Manager's Note: The five manuscripts referred to above form the next portion of this report. Only their physical formats, *e.g.* margins, fonts, spacing, *etc*., have been altered.)

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On the Influence of Downwelling Winds on the Chesapeake Bay Outflow, by Arnoldo Valle-Levinson and Kamazima M. M. Lwiza.

Rapid Assessment of Current Velocities in the Coastal Ocean, by Arnoldo Valle-Levinson and Kamazima M. M. Lwiza.

On the Influence of Estuarine Outflow and Bathymetry on Semidiurnal Tidal Currents, by Andrew G. E. Haskell, Arnoldo Valle-Levinson and Kamazima M. M. Lwiza.

Hydrographic and Flow Structure in the Chesapeake Bay Mouth and Plume Region Under High Freshwater Discharge Conditions, by Kristine Holderied and Arnoldo Valle-Levinson.

Flow Patterns at the Chesapeake Bay Entrance, by Arnoldo Valle-Levinson, Chuyan Li, Thomas C. Royer and Larry P. Atkinson.

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